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ABSTRACT

Application of the programing process to the production of instructional games is described in seven steps: task analysis and specification of objectives, design of criterion measures, designing the game, editing, developmental testing, validation testing, and developing the instruction manual. (LS)

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DESIGN, DEVELOPMENT AND VALIDATION OF INSTRUCTIONAL GAMES[1]

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Design, Development and Validation of Instructional Games

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Let's watch Cheryl, Pete and Tom play a game of MALC.

They begin by drawing cards from a shuffled deck to determine who is going to be the "teacher," the "tester" and the "pupil." Cheryl gets to be the teacher and she opens a random page of the GAME BOOK. She and Ted (the tester) see what is on the page. It says:

> A MALC is a set of three cards, the first card a black one, the second red, and the third black.

The object of the game is for Cheryl to teach this "concept" to Pete, the pupil. She has to do this by showing various three-card sets to Pete and telling him whether each set is a MALC or not. For example, Cheryl would show Pete this set and say, "This is a MALC":

7 C, 3 D, 5 S

And when she shows him this set, she would say, "This is not a MALC":

5 H, 7 S, 7 D

The teacher is not permitted to say anything else. Pete is not permitted to say anything at all except, "Ready for the test" whenever he feels that he has figured out the concept.

At this stage, Ted steps in. He lays down new sets of three cards and tests Pete by asking him, "Is this a MALC?" If Pete responds correctly to ten consecutive test sets, the game ends. If he makes an error before the tenth set, the game reverts to the previous (teaching) phase. Whenever Pete passes the test, the total number of teaching sets used are subtracted

from the "par" for the concept. This gives the score for both the teacher and the pupil.

At lease three rounds have to be played to complete a set of MALC. Each player gets to be the teacher, the pupil, and the tester. At the beginning of each game, the teacher chooses a new concept by flipping to another page of the GAME BOOK. At the end of the third game, the score sheet would look something like this:

	Player: CHERYL	Player: Pete	Player: Ted
Game 1	Teacher 9	Pupil 9	Tester —
Game 2	Tester —	Teacher 14	Pupil 14
Game 3	Pupil 12	Tester —	Teacher 12
Set I	21	23	26

Ted, with his total score of 26, is the winner. Other variations in the scoring method enable us to find the champion teacher and the champion learner separately.

MALC is one of a number of training games we are now developing at the Center for Research and Development in the Improvement of the Teaching of Handicapped Children. The brief description above does not reveal the process of designing, testing, revising and validating which went into its production. Creating an instructional game requires the skills not only of a good game designer but also an effective instructional programer. This article describes the application of the programing process to the production of instructional games.

Step 1. Task analysis and specification of objectives

As in any other type of instructional development, the development of an instructional game begins with a task analysis and definition of what the learner is to know, do, and feel at the end of instruction. In analyzing the cognitive aspects of an instructional task for a game, we have to pay attention both to the content and to the processes. Games are extremely suitable for teaching the latter: Such things as the procedure for problem solving, strategy for bargaining, and techniques of teaching lend themselves to the design of effective games. Specific kinds of content (terminology, facts, concepts, and principles) are usually picked up incidentally while playing games.

Games are extremely effective for helping the learners attain various affective objectives. Here is a list of such outcomes:

1. motivate the learner toward sustained activity
2. encourage the learner to try out alternative solutions rather than depend on a single one
3. sensitize the learner to the complexity of the situation and to the interaction among various factors

As a specific example, we derived the following objectives for the game MALC:

COGNITIVE

Content. The student shall demonstrate an understanding of the concepts of concept, critical and irrelevant attributes, and examples and nonexamples.

Process. The student shall teach a concept using an effective set of examples and nonexamples.

The student teacher shall construct, administer, and interpret a diagnostic test for concept acquisition.

AFFECTIVE

The student shall appreciate

-the complexity of teaching a concept for real understanding

-the efficiency of teaching a concept through the use of a rational set of examples and nonexamples

-the validity of a generalization-discrimination test for checking the real understanding of a concept

Step 2. Design of criterion measures

The next step in the empirical design of a game is the construction of various tests to measure the attainment of objectives. Cognitive content objectives could be checked through paper-and-pencil tests while process objectives require a performance test. Since our aim is not merely to develop good game players but also good performers in the criterion situation, these tests should measure transfer. If the game involves a simulation of driving a car, for example, the test should involve actual driving.

Many of the affective objectives lend themselves to direct observation. For example, the motivational strength of the game becomes obvious when the players protest against terminating the game. Apart from spontaneous comments during and after play, a structured interview may be used for measuring different affects. A random sample of players could be interviewed in a short time to get representative feedback.

Many of the tests are primarily used during the development and validation of the game. Once we have established that the game consistently produces prespecified results, it is hardly necessary to test the players after each game.

We have devised the following measuring instruments for use with MALC:

1. a paper-and-pencil test to measure the students' understanding of various concepts. This test contains a number of

novel examples and close-in nonexamples of the different concepts and requires the student to classify them.

2. A performance test to measure the student's ability to transfer his skills to concept-teaching situations. The student is required to choose a concept from his own discipline, generate suitable examples and nonexamples and structure them into a teaching sequence.

3. An interview schedule. This is used with a random sample of approximately ten percent of the players to determine the affective outcomes of the game.

Step 3. Designing the game

There is no better training for becoming a game designer than learning, playing and analyzing a large number of games. Participating in a game gives an excellent appreciation of the players' point of view. The few time-tested basic formats for games could be learned from books on party games, and table, board and card games. These basic formats may be adapted to suit different instructional objectives and different learning situations.

Many instructional games simulate some real-life situation, and one of the first decisions to be made is how much reality is to be incorporated into the game. Generally, it is difficult to increase the fidelity of simulation without also increasing the complexity of the game. An ideal game would strike a balance between reality and complexity.

Having decided upon which aspects of reality to simulate, the next task is that of translating real-life variables into game variables. This usually begins with the establishment of the "win criterion" for the game. This is a restatement of the instructional objectives in terms of

the format of the game and the scoring system. The playing procedure for the game to reach this criterion is then worked out. This involves setting up the necessary and sufficient set of rules. Decisions about equipment and materials could now be finalized.

Only rarely does the design of a game follow the smooth linear process implied in the above description. It is primarily a task of shifting, moving and rearranging. Here is the reconstructed logic of the design of MALC:

MALC attempts to simulate the teaching and learning of concepts. It depicts Markle and Tiemann's (1969) idealized concept-teaching model which de-emphasizes meaningless verbalism and equates real understanding of a concept to the learner's ability to make novel generalizations and fine discriminations. MALC is based on Robert Abbot's (1963) game Eleusis. The three players in the game represent the teacher, the learner and the tester. Concepts are represented by sets of cards with defined attributes; the teaching and testing processes by holding up example and nonexample sets. The win criterion of enabling the learner to pass the discrimination-generalization test in as few trials as possible reflects our belief in the nature of efficient concept teaching in the classroom. The rules of the game are tailored to this criterion.

Step 4. Editing

Although the final judges of the effectiveness of a game are its players, expert opinion could be used to evaluate and improve it initially. Suggestions from editors usually differ from those arising out of student feedback. However, both are equally important.

We use the editorial checklist which is reproduced below. Each criterion is followed by a specific example from MALC.

1. Simplify the rules of play.

Avoid irrelevant embellishments. Do not attempt to imitate real life in all its complexity. If the responsibilities of any player become too complicated, divide them up for two or more players. Or, design a companion game.

The original version of MALC had just two players: the teacher and the pupil. The teacher did the testing also. The simplified version assigns the job of testing to a third player.

2. Make sure that the rules of the game are fair.

Do not give any undue advantage to any particular player. The rules should be freely acceptable to all players.

Sometimes the real-life counterparts of some of the players do have certain undue advantages which are reflected in the game. However, these inequalities could be balanced out by periodically changing the roles of the players. In playing a set of MALC, for example, each player gets a chance to be the teacher, the pupil and the tester.

3. Simplify the scoring system.

You should not require somebody with a slide rule to figure out the scores. Ideally the scores should be obvious at a glance to any player anytime during the game.

The scoring system for MALC is still slightly complex. However, compared to the original method, the use of different "pars" and the special scoring sheet has simplified it to a great extent.

4. Make sure that all players participate throughout the game.

In a game in which the players have different roles, check to see that all of them have something to do all the time.

In the original version of MALC, the tester had nothing to do until the teaching phase ended. In the present version, by showing him the concept at the beginning, we keep him busy making up his test. Also he keeps score during the teaching phase. Apart from keeping the tester happily occupied, these rules speed up the game considerably.

5. Eliminate elimination.

Many game formats require a player to be dropped out of the game as a penalty or as soon as he gets rid of certain objects. Although this adds excitement to the game, it reduces its instructional value.

MALC does not have this problem.

6. Permit fair competition between players of varying abilities by building in handicapping arrangements.

In MALC this could be accomplished by adjusting the par values according to the player's ability. Alternatively the advanced player may be required to choose a complex concept while the beginner picks up an elementary one.

7. Keep each round of the game as brief as possible so that it may be played repeatedly.

Given a choice, there is more flexibility and effectiveness in a game which could be played 12 times in an hour than playing a single game for the same period. In some games, it may be possible to set up a time limit, although this may not be possible with an ambitious simulation game.

A round of MALC lasts for a relatively brief period of about 15 to 20 minutes.

8. Change the roles of the players frequently.

To provide a complete understanding of different points of view, simulation games should require each player to assume diametrically opposite roles: teacher-student, parent-child, producer-consumer, etc. Gotkin (1970) lists transaction (i.e., role reversal) as one of the important requirements for a game to teach interdependency.

Since each round of MALC takes up only a short time, it is possible to transfer the roles of the teacher, pupil and tester systematically.

9. Make sure that winning the game depends upon reaching your objectives and not on some other irrelevant skill.

To borrow an example from Gotkin (1970), consider a game in which the first child to run to the chalkboard and circle a given letter is the winner. The objective of this game is rapid discrimination whereas what is being rewarded is fast running.

In MALC, bridge players easily perceive the differences between major and minor suits; rummy players see "around-the-corner" sequences; and poker players perceive various subtle relationships among the cards. To compensate for the players' unequal experiences with playing cards, we have added an explanatory section to the instructional manual. This makes the pupils' acquisition of the concept more directly dependent on the teacher's skill.

10. Control the amount of chance.

If the game depends entirely upon the fall of cards or throw of dice, there is not much scope for skill and learning (except, perhaps,

learning probability theory). On the other hand, if the game is entirely dependent upon skill, ot loses its play aspect.

> The original version of MALC required the teacher to deal sets of three cards from the shuffled deck and inform the pupil whether each was a MALC or not. This left everything to chance. On the other hand, letting the teacher choose his own MALC as well as the example sets, left everything under the teacher's control. In this situation, he could become a super specialist on a pre-determined set of MALCs and conduct a series of replications rather than play the game. The current set of rules for MALC seems to optimize the chance factor.

Step 5. Developmental testing

The next step is the actual tryout of the game. Begin by playing the game with your friends for the preliminary debugging of your creations. Start with a minimum set of rules. You could always add more rules if necessary. Allow the players to come up with ad hoc rules and minor variations. Record all spontaneous comments and suggestions. A tape recorder would be handy for doing this without interrupting the player. You could get a lot of feedback by watching the players' reactions. Immediately at the end of the game, hold a debriefing session. Since you already have a fairly good picture of the motivational value of the game from your observations during play, you could now concentrate upon measuring its instructional effectiveness.

During developmental testing, making revisions is more important than collecting data. Here again, remember your dual goals: entertainment

and education. You should avoid making the game too interesting to be instructive or too informative to be inviting.

Minor changes in the rules could be made during the play of the game itself. Major modifications in the equipment or in the basic format should be undertaken between plays. All revisions should be retested with both the previous group and a fresh group: the former to assure you that you have not made the game worse and the latter to give you fresh feedback. Our experience indicates that four or five revision-retest cycles are sufficient to eliminate all major defects in a game.

Preliminary developmental testing of MALG was carried out with our regular game group. Many aspects of the current version actually evolved out of these sessions. Some of the suggested revisions were not implemented since they would have reduced the instructional value of the game. For example, asking the pupil for a mere verbal definition in the test phase would have speeded up the game considerably. However, this would result in a complete neglect of one of the important skills to be learned: that of construction of diagnostic discrimination-generalization tests. Three other tryouts (each preceded by a thorough revision) were conducted with volunteer players from an undergraduate educational psychology course and a course on programmed instruction.

Step 6. Validation testing

In its simplest form, validation testing of a game consists of testing a group of students before and after playing the game, thus:

Pretest ——————→ Game ——————→ Posttest

Tests constructed in Step 2 are used as both pretests and posttests.

Additional tests could be used during the pretest session to determine the entry characteristics of the validation group.

If the game is of a relatively brief duration and the players free from external influences, most of the sources of invalidity for this type of design could be controlled. For longer games or repeatedly-played ones, students could be randomly assigned to the game group and to the control group.

Game Group	Pretest ⟶ Game ⟶ Posttest
Control Group	Pretest ⟶ Posttest

The control group takes the pretest and the posttest along with the game group but does not play the game or receive any other form of instruction between the tests. The differences is the gains of the two groups are mainly attributable to the effect of the game.

In a majority of instructional situations, it may not be possible to withhold instruction from the control group. In these cases, we may compare the gains of the game group with a control group receiving a different type of instruction. Better still, we could use three random groups to compare the game to the two extreme instructional strategies of classroom lectures and on-the-job training.

The ultimate purpose of validation testing is to demonstrate the effectiveness of the game to its potential user. A teacher planning to use the game would want to know who learns what under what conditions in how much time (Markle, 1967). Hence, the validation report should contain detailed descriptions of, and data on, the following:

1. Characteristics of the students used in validation testing: age, sex and grade level

IQ, aptitude and achievement score (in the area related to the game)

previous exposure to the situation simulated in the game

previous experience with instructional games

attitude toward games

scores on tests of prerequisite knowledge and skills

scores on tests measuring the objectives of the game

2. Instructional situation:

complete description of the game

equipment, materials and space requirements

teacher's role

other teachers' attitudes toward games

3. Outcomes:

gains in achievement

gains in attitude

motivation gains

students' perception of the relevance of the game to the instructional objectives

acceptance of the game by other instructors

disruption of other procedures

4. Time requirements:

time to set up the equipment, etc.

time for introducing the game

actual play time

time for follow-up activities

MALC has been validated with a small group of nine players from a course on programmed instruction. Before and after playing the game, the students were tested on their under-

standing of, and attitude toward, a variety of concepts involved in the game. The students were also given a transfer test which required them to design an instructional program and a diagnostic test for a concept of their own choice using strategies from the game. The results of all these tests are extremely encouraging.

The instruction manual

The previous step completes the development of the game. However, the game has to be taught to the players. The game designer has to prepare instructional materials which may range all the way from a single sheet of rules to a comprehensive trainer's manual. These instructional materials are designed, edited, tried out and validated just as the game itself. Since the ability of the game to help the players attain the instructional objectives has already been validated, developmental testing of the instructional materials would concentrate upon its effectiveness to teach the mechanics and the strategy of the game. It is always a good idea to teach the mechanics of the game first and let the players play a few games before teaching them any strategy. The conventional Hoyle format for the instruction manual suggests the following sections:

General description of the game

Number of players

Duration of the game

Equipment

Object of the game

Preliminaries

The play

Scoring

Ending the game

Special rules

Variations

Strategy

A sample game

The manual for MALC contains most of these sections. It begins with a sample game to give the learners a general overview. This is followed by a formal rule book section. Then there is a simulated simulation in which the learner plays with the book. Variations of MALC for team play are also given. A final section on the strategy of MALC explains how to analyze the MALC, how to set up teaching examples and nonexamples and how to construct a tough test.